Experience of IQM at Southampton for SRS cases

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Background

Elements treatment planning system (*Brainlab Limited, Germany*) and Integral Quality Monitor (IQM, *iRT Systems GmbH, Germany*) were acquired in our department to enable single isocentre treatment for multiple brainmets (MBM) and patient specific dosimetry (PSD) for Elekta Agility Versa HD linac.

Fig. 1: IQM attached to linac head for measurement (left) Elements single isocentre treatment plan for 7 MBM (right)

Background

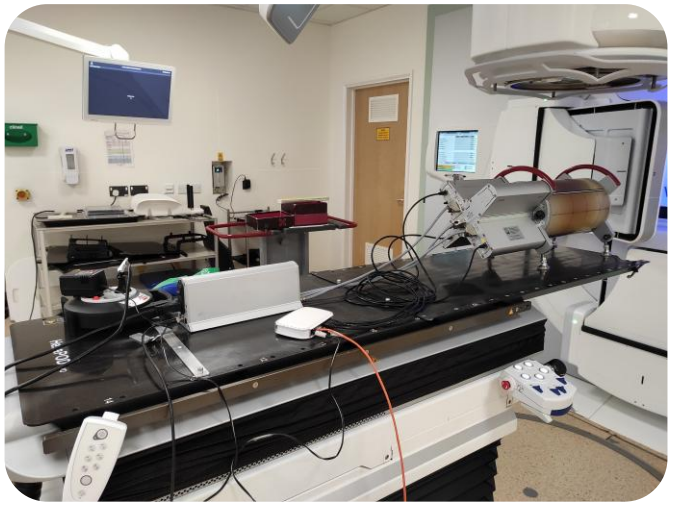
- Individual isocentres for each lesion, if treating 10 isocentres for a 10 lesions plan, typically 5 arcs per isocentre → single isocentre treating multiple brainmets.

- Point dose measurements with Lucy phantom using A26 Exradin Chamber

- Additional D4 measurements for multiple lesions → IQM measurements

(a) Exradin A26 Chamber, Standard Imaging

(b) Lucy Phantom, Standard Imaging



(c) Delta4 Phantom, Scandidos, Sweden

Fig. 2. Dosimetry equipment used for patient specific dosimetry @ UHS

Solitary Lesion measured on D4

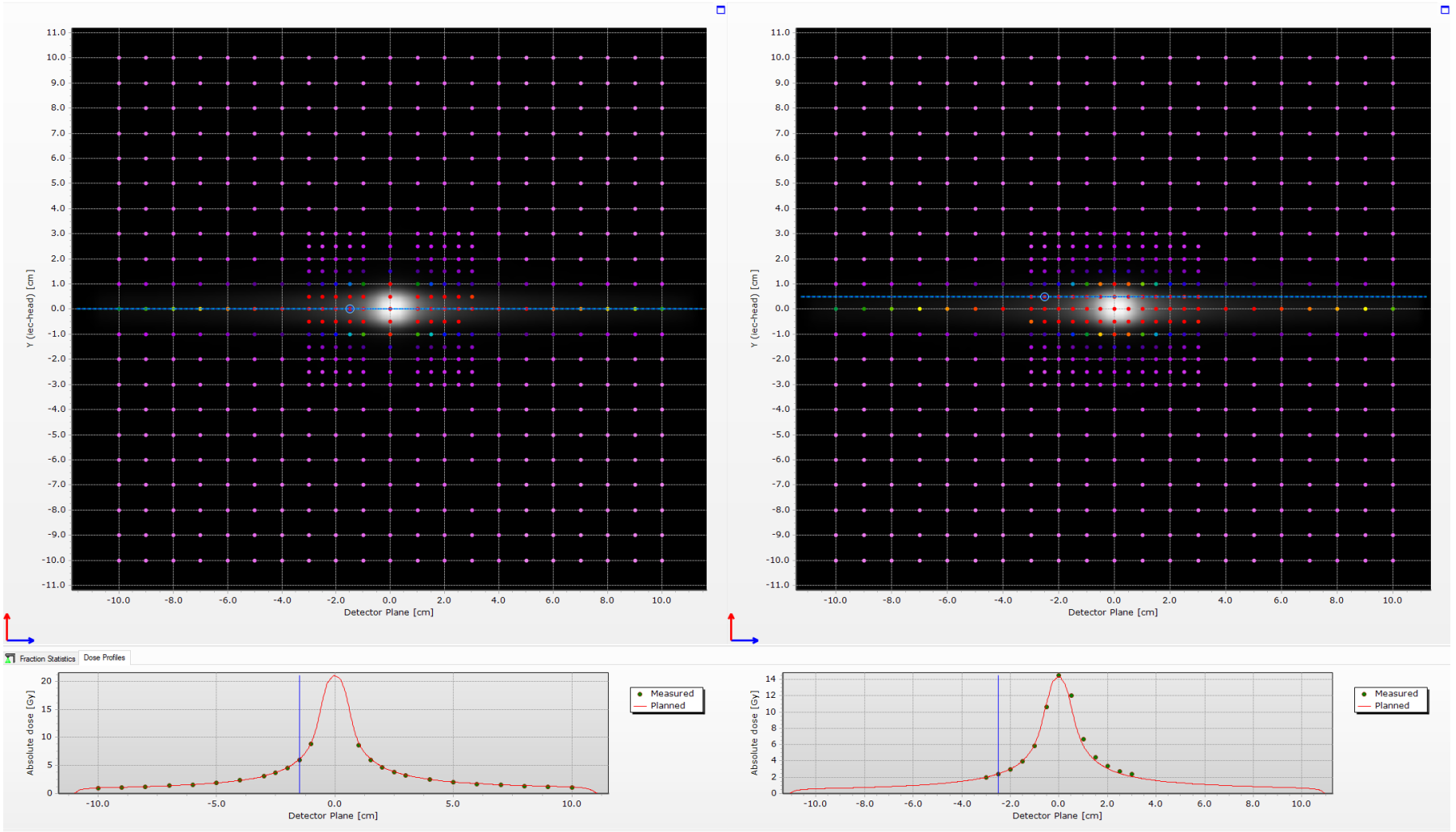


Fig. 3. 2D planar dose and beam profiles of a solitary brainmet plan

Multiple Lesions measured on D4

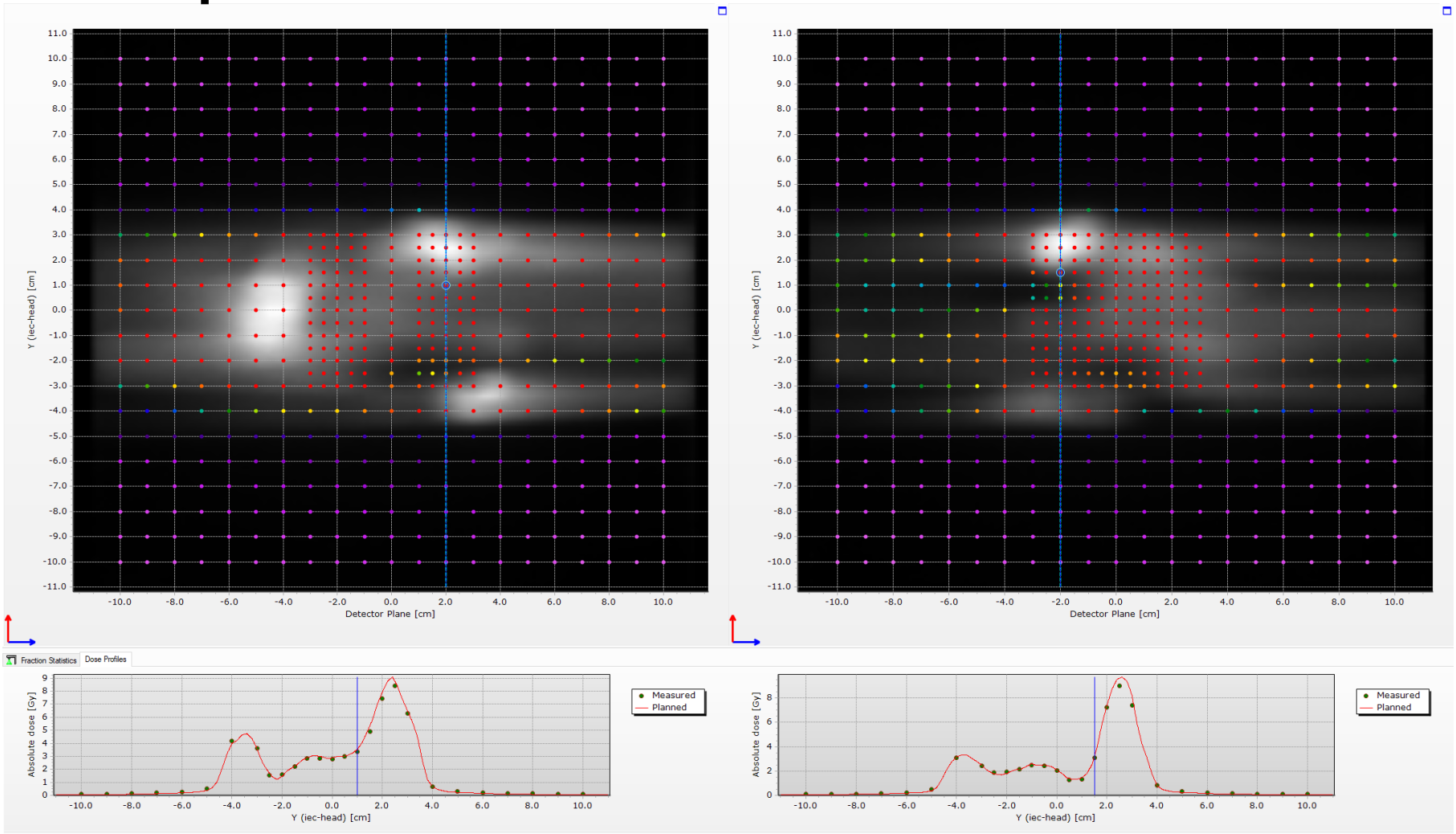


Fig. 4. 2D planar dose and beam profiles of a multiple brainmets plan

Method

The IQM system was originally commissioned for field sizes from 1x1 cm^2 and above as per default manufacturer requirement. This did not include very small fields of sub centimetre field sizes that are relevant for stereotactic treatments at the time of installation in 2022. To improve IQM beam model accuracy, additional area output factors were measured for very small field sizes down to 0.3x0.5 cm^2 as highlighted in yellow in below.

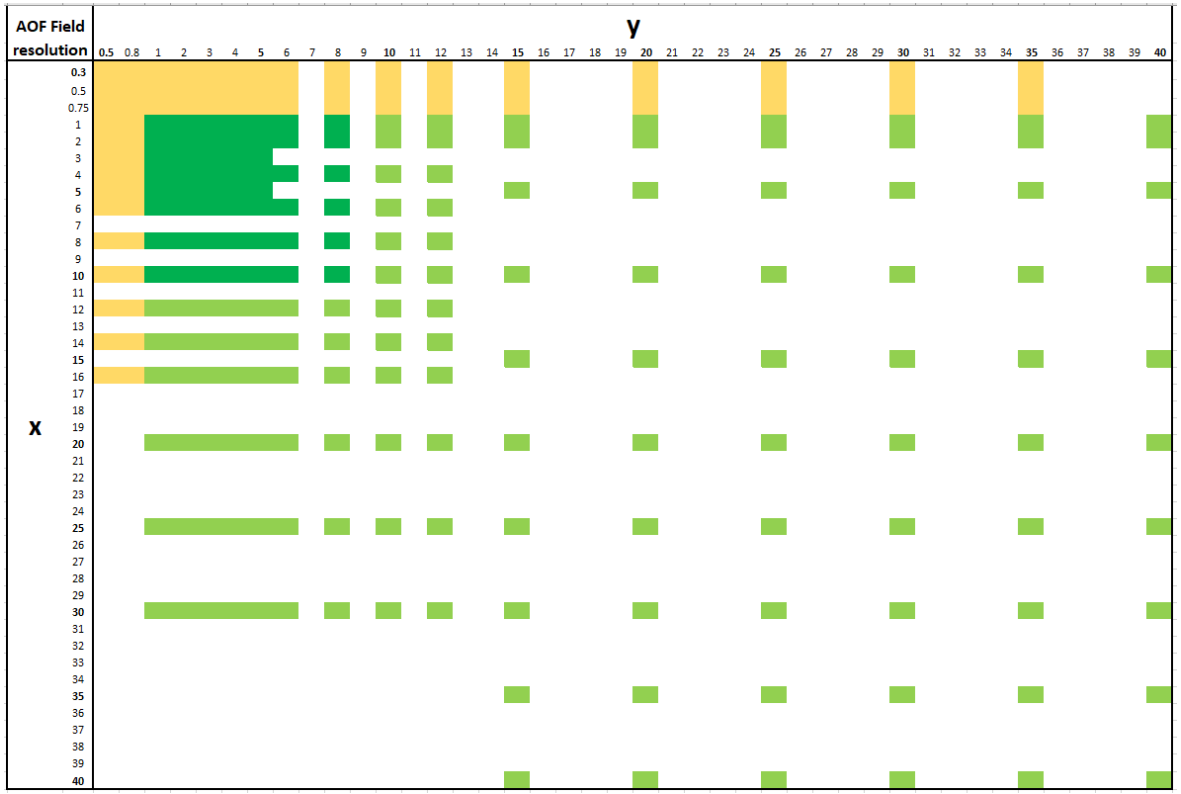


Fig. 5: List of small field area output factors measured to improve small field IQM beam modelling

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Picture Courtesy: iRT Systems GmBH, Germany

Method

- Treatment plans were generated for solitary brainmets and single isocentre treating 2-7 MBM for 20 patients.

- Treatment plan files for each plan were exported for IQM reference signal calculation after which the plans were measured with IQM.

Results

- Agreement of measurements against the calculated cumulative and segment-by-segment signal were assessed for all the plans.
- A total of 128 arcs and 1903 segments were evaluated.
- Distribution of data points and segment-by-segment deviation measured against the field size.

Results

Distribution of Datapoints			AOF-Y [cm]															
			0.5	0.8	1	2	3	4	5	6	8	10	12	15	20	25	30	35	40
			0.0	0.6	0.9	1.5	2.5	3.5	4.5	5.5	7.0	9.0	11.0	13.5	17.5	22.5	27.5	32.5	37.5
			0.6	0.9	1.5	2.5	3.5	4.5	5.5	7.0	9.0	11.0	13.5	17.5	22.5	27.5	32.5	37.5	40.0
AOF-X [cm]	0.36	0.0	0.4						8		39	50							
	0.5	0.4	0.6					15	72	26	43	71	39						
	0.75	0.6	0.9		34	55	11	20	17	14	69	38	15						
	1	0.9	1.5		65	303	30	55	73	2	7	40	15						
	2	1.5	2.5			231	263	2											
	3	2.5	3.5				19												
	4	3.5	4.5																
	5	4.5	5.5																
	6	5.5	7.0																
	8	7.0	9.0																
	10	9.0	11.0																
	12	11.0	13.0																
	14	13.0	15.0																
	16	15.0	18.0																
	20	18.0	22.5																
	25	22.5	27.5																
	30	27.5	32.5																
	35	32.5	37.5																
	40	37.5	40.0																

Fig. 6a: Distribution of data points measured against the field size

Picture Courtesy: iRT Systems GmBH, Germany

Results

◉ Deviations ○ AOF			AOF-Y [cm]															
			0.5	0.75	1	2	3	4	5	6	8	10	12	15	20	25	30	35	40
Shading Limits	> ± 3.0%		0.0	0.6	0.9	1.5	2.5	3.5	4.5	5.5	7.0	9.0	11.0	13.5	17.5	22.5	27.5	32.5	37.5
	> ± 4.0%		0.6	0.9	1.5	2.5	3.5	4.5	5.5	7.0	9.0	11.0	13.5	17.5	22.5	27.5	32.5	37.5	40.0
AOF-X [cm] 0.36	0.0	0.4							-1.7		0.4	0.5							
0.5	0.4	0.6						1.4	0.0	1.4	1.0	-0.3	-0.9						
0.75	0.6	0.9			-1.4	0.2	-0.3	2.5	1.2	1.6	0.3	-0.6	-0.1						
1	0.9	1.5			-2.2	-0.9	1.5	0.2	2.3	-0.9	-1.0	-1.0	-1.3						
2	1.5	2.5				0.4	0.6	2.6											
3	2.5	3.5					-1.3												
4	3.5	4.5																	
5	4.5	5.5																	
6	5.5	7.0																	
8	7.0	9.0																	
10	9.0	11.0																	
12	11.0	13.0																	
14	13.0	15.0																	
16	15.0	18.0																	
20	18.0	22.5																	
25	22.5	27.5																	
30	27.5	32.5																	
35	32.5	37.5																	
40	37.5	40.0																	

Fig. 6b: Distribution of average segment-by-segment deviation measured against the field size

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Picture Courtesy: iRT Systems GmBH, Germany

Results

- The average segment-by-segment deviation between calculated and measured IQM signals for small fields were found to be within 3%.
- All clinical test plans matched the final cumulative signal deviation criteria.
- All measured clinical test plans passed the watch and action level set on the cumulative signal.
- However, only 15/20 clinical plans passed the segment-by-segment pass rate which was attributed to high signal fluctuations between the measured control points.
- But these clinical plans were found to be within the watch level.

Results

Cumulative Evaluation:

Output			
Amount of evaluated Fields		128	
Amount of evaluated Segments		1903	
Tolerance Parameters			
Watch Level	Constant Watch	3.00	
	Slope (+ / -)	-0.6361	-0.6361
	ΔSbS (+ / -)	13.92	13.92
Action Level	Constant Action	6.3	6.3
	Slope (+ / -)	-0.6361	-0.6361
	ΔSbS (+ / -)	27.85	27.85
Regression Range	Regression Until CP# (+ / -)	11	11
	Regression starting at CP#	1	
Data Evaluation			
% of Signals within reg. Watch Level		99.00%	
% of Signals within const. Watch Level		98.99%	
% of Signals within full Watch Level		99.00%	
Average Deviation (at constant Tolerance)		0.00 ± 1.25%	
Average Final Deviation		0.08 ± 1.21%	
Code Strings for IQM.Config.ini-File			
Watch Level	13.9,1, 9,2, 6.9,3, 5.8,4, 5,5, 4.5,6, 4,7, 3.7,8, 3.4,9		
Action Level	27.8,1, 17.9,2, 13.8,3, 11.5,4, 10,5, 8.9,6, 8.1,7, 7.4		

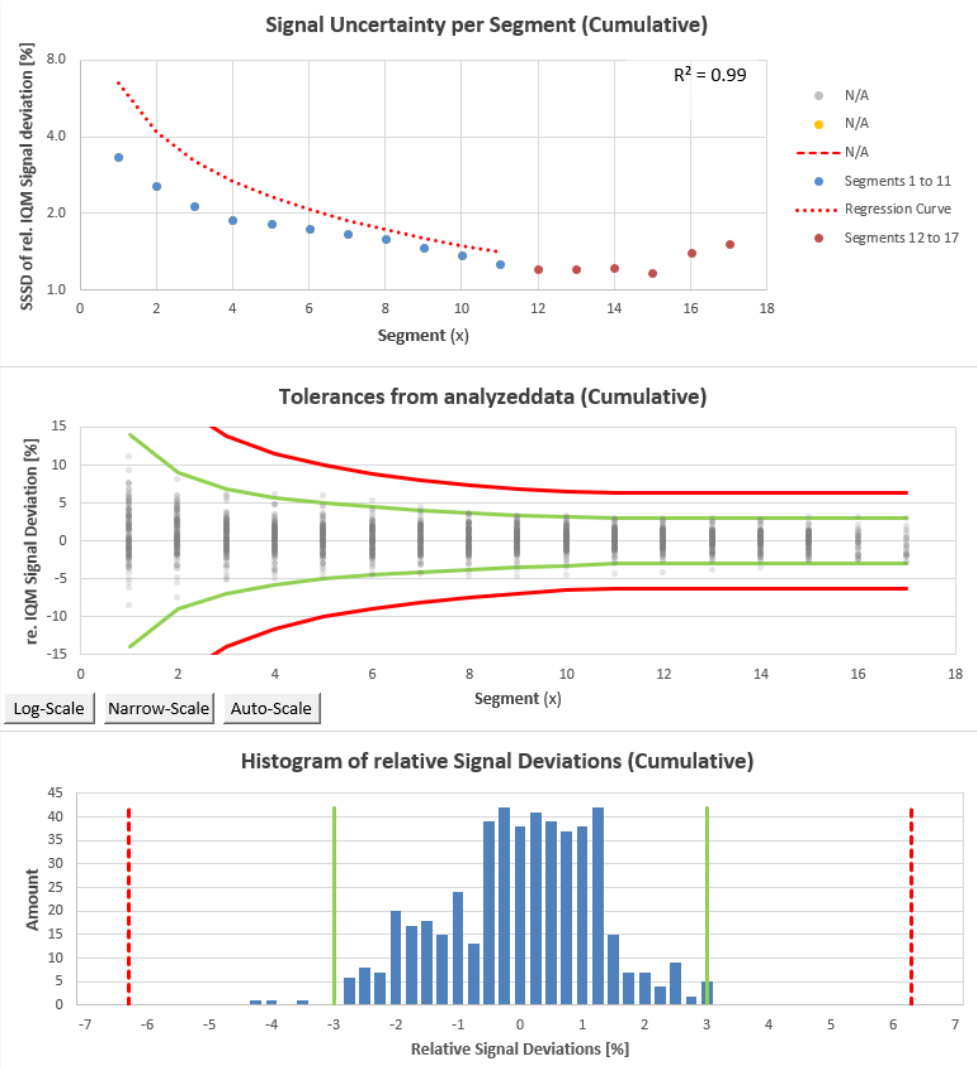

Fig. 7a: Measured cumulative deviation against the watch and action level tolerance corridors

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Picture Courtesy: iRT Systems GmBH, Germany

Results

Segment-by-Segment Evaluation:

Output			
Amount of evaluated Fields		128	
Amount of evaluated Segments		1903	
Tolerance Parameters			
Watch Level	Constant Watch	6.00	
	Slope (+ / -)	1.0000	1.0000
	ΔSbS (+ / -)	8.00	8.00
Action Level	Constant Action	12.0	12.0
	Slope (+ / -)	1.0000	1.0000
	ΔSbS (+ / -)	16.00	16.00
Regression Range	Regression Until CP# (+ / -)	1	1
	Regression starting at CP#	1	
Data Evaluation			
% of Signals within reg. Watch Level		97.66%	
% of Signals within const. Watch Level		97.63%	
% of Signals within full Watch Level		97.64%	
Average Deviation (at constant Tolerance)		-0.03 ± 2.51%	
Average Final Deviation		-0.54 ± 3.18%	
Code Strings for IQM.Config.ini-File			
Watch Level	8,1, 6		
Action Level	16,1, 12		

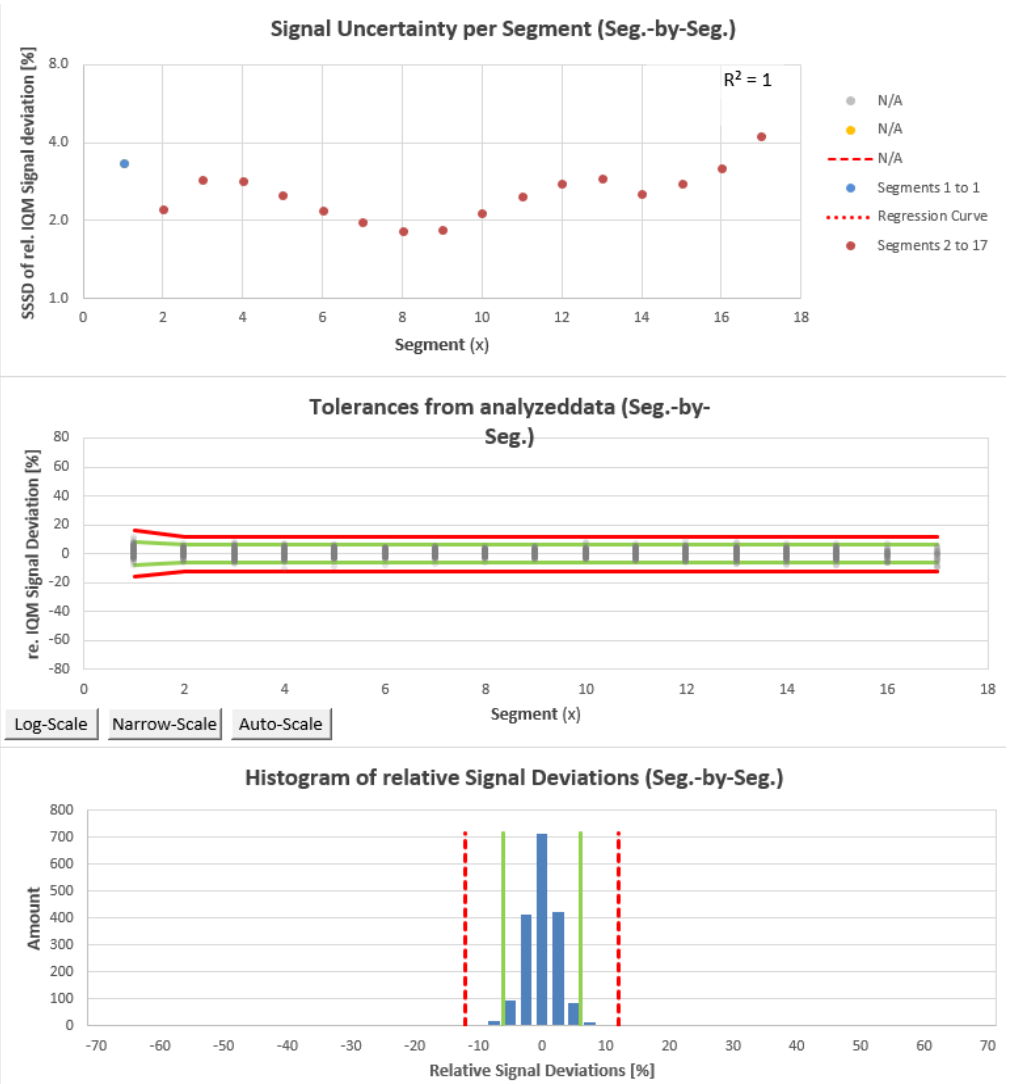

Fig. 7b: Measured segment-by-segment deviation against the watch and action level tolerance corridors

Picture Courtesy: iRT Systems GmBH, Germany

Conclusion

IQM system was successfully implemented for PSD of single isocentre treatment for MBM planned using Element TPS.

Thank you!!

Acknowledgements

Radiotherapy Physics Colleagues @ Southampton,
Brainlab Limited, Germany for Elements beam modeling
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